Extended abstract

Habitat selection by non-breeders helps predict the breeders distribution in two penguin species

by

Jean-Baptiste THIEBOT* (1), Amélie LESCROËL (1), David PINAUD (1),
Philip N. TRATHAN (2) & Charles-André BOST (1)

Habitat selection by marine predators is increasingly well studied as a consequence of telemetry techniques. For land-breeding species such as seabirds, however, knowledge about their habitat use has mainly been gained through studies of breeding individuals that are constrained to return frequently to their breeding grounds. In this study, we set out to measure (a) whether marine predators showed a larger at-sea range during the non-breeding period than during the breeding period and (b) if breeding individuals concentrated their activity only on the closest suitable habitats. Macaroni [*Eudyptes chrysolophus* (Brandt 1837)] and gentoo [*Pygoscelis papua* (Forster 1781)] penguins were remotely tracked from the Kerguelen archipelago, where they are sympatric (Weimerskirch *et al*., 1988). These two marine predators contrast in their foraging strategies, notably on foraging range and diving capacities (Mori and Boyd, 2004). For macaroni penguins, our investigation of habitat use outside the breeding period was based on the inter-breeding migration of 12 animals tracked using light-based geolocation methods in 2006 (see Bost *et al*., 2009). Data on the breeding period were obtained by satellite-tracking three adult males between December 2000 and January 2001 during the chick-brooding stage. Habitat use by gentoo penguins outside their breeding period was investigated using six dispersing juveniles satellite-tracked in 2008 from two colonies (open sea *versus* Morbihan Gulf). During the breeding period, 11 adult gentoos from open sea and Morbihan Gulf colonies were satellite-tracked in September and October 2002 (see Lescroël and Bost, 2005). The non-breeding penguins' habitat selection was investigated through Mahalanobis distances factorial analysis, a method of habitat suitability modelling based on the principle of ecological niche in a set of available environmental conditions (Calenge *et al*., 2008). In each species, modelled habitat selection criteria were then applied within the theoretical foraging ambit of animals during the breeding period in order to verify if we could predict the actual tracks of the breeding animals from the habitat selected outside the breeding period. Our results validated our first prediction. Macaroni penguins showed an 11-fold increase in their at-sea time between chick-brooding and inter-breeding trips, which was associated with significantly greater maximum range (6.8 times more) and minimum distance travelled (12.2 times more). For gentoo penguins, the same pattern was also observed although the juvenile dispersal was not exhaustively covered by the telemetric survey. Maximum range was at least 6.9 times more than for breeding individuals, while the distance travelled was at least 6.3 times more. Our second prediction (that is, that breeding animals only exploit the closest suitable habitats) was also largely supported by both study models. The tracks of breeding individuals appeared to closely match with the nearest suitable habitats predicted by the larger-scale behaviour of non-breeding birds. On Kerguelen, the two penguin species appear to segregate in space, with a strongly contrasting use of the Kerguelen Plateau. Macaroni penguins appeared to target areas beyond the shelf break in both breeding and inter-breeding periods, while gentoo penguins appeared to be always restricted to the shelf area, with individuals from the Morbihan Gulf being coastal foragers. Although some caution is required due to our limited sample sizes and possible inter-annual effects, our study confirms that the breeding period is associated with a reduction in the available habitat for central-place foraging animals such as seabirds, which primarily suggests that mechanisms and criteria for habitat selection are similar during and outside the breeding periods, given the available environment. These conclusions are relevant for the two species studied in this work, even though they are contrasting species. Environmental variability, including seasonal effects of prey (Ainley *et al*., 2004), potentially drives the larger-scale movements observed outside the breeding period. We suggest that this non-breeding period is of particular interest when attempting to understand an animal's habitat selection.

Acknowledgements. - The Ethics Committee of Institut Polaire Français Paul-Émile Victor approved all field procedures. The authors thank Y. Charbonnier, S. Mortreux, R. Perdriat, J. Nezan, V. Chartendraux, E. Pettex, C. Marteau, J.-L. Chill and F. Le Bouard for their help in the field and A. Goarant, A. Villers, C. Péron, A. Pinot for their help and advice with the analyses. The present work was supported financially and logistically by the ANR 07 Biodiv 'GLIDES', the Zone Atelier Antarctique (INSU-CNRS), the Institut Polaire Français Paul-Emile Victor (IPEV, programmes no. 394 and 109) and the Terres Australes et Antarctiques Françaises administration.

Key words. - Ecological niche - Penguins - Central-place foragers - Winter - Juvenile - Kerguelen archipelago.

(1) Centre d'études biologiques de Chizé, UPR 1934 CNRS, 79360 Villiers-en-Bois, France. [amelie.lescroel@univ-rennes1.fr] [pinaud@cebc.cnrs.fr] [bost@cebc.cnrs.fr]
(2) British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, UK. [pnt@bas.ac.uk]
* Corresponding author [thiebot@cebc.cnrs.fr]

REFERENCES

AINLEY D.G., RIBIC C.A., BALLARD G., HEATH S., GAFFNEY I., KARL B.J., BARTON K.J., WILSON P.R. & WEBB S., 2004. - Geographic structure of Adélie penguin populations: overlap in colony-specific foraging areas. *Ecol. Monogr.*, 74: 159-178.

BOST C.A., THIEBOT J.B., PINAUD D., CHEREL Y. & TRATHAN P.N., 2009. - Where do penguins go during the inter-breeding period? Using geolocation to track the winter dispersion of the macaroni penguin. *Biol. Letters*, 5: 473-476.

CALENGE C., DARMON G., BASILLE M., LOISON A. & JULIEN J.M., 2008. - The factorial decomposition of the Mahalanobis distances in habitat selection studies. *Ecology*, 89: 555-566.

LESCROËL A. & BOST C.A., 2005. - Foraging under contrasting oceanographic conditions: the gentoo penguin at Kerguelen Archipelago. *Mar. Ecol. Prog. Ser.*, 302: 245-261.

MORI Y. & BOYD I.L., 2004. - Segregation of foraging between two sympatric penguin species: does rate maximisation make the difference? *Mar. Ecol. Prog. Ser.*, 275: 241-249.

THIEBOT J.-B., LESCROËL A., PINAUD D., TRATHAN P.N., BOST C., 2011. - A. Larger foraging range but similar habitat selection in non-breeding versus breeding sub-Antarctic penguins. *Antarct. Sci.*, 23(2): 117-126.

WEIMERSKIRCH H., ZOTIER R. & JOUVENTIN P., 1988. - The avifauna of the Kerguelen Islands. *Emu*, 89: 15-29.